Computer Programming (a) - E1123

(Fall 2021-2022)

Lecture 4

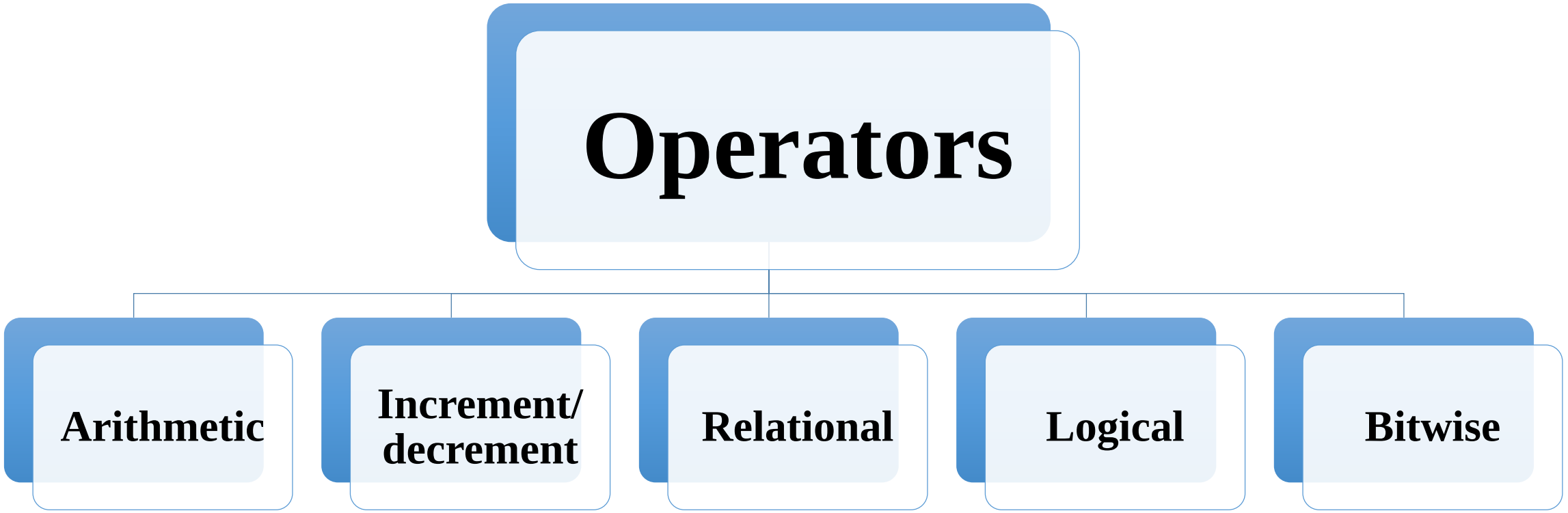
Operators and Control Structures

INSTRUCTOR

DR / AYMAN SOLIMAN

➢ Contents

1) Operators
2) Control Structures
3) Conditions
4) One-Way Selection
5) Two-Way Selection
6) Multiple Selections: Nested if
7) switch Structures


Operators
Arithmetic
Increment/ decrement
Relational
Logical
Bitwise

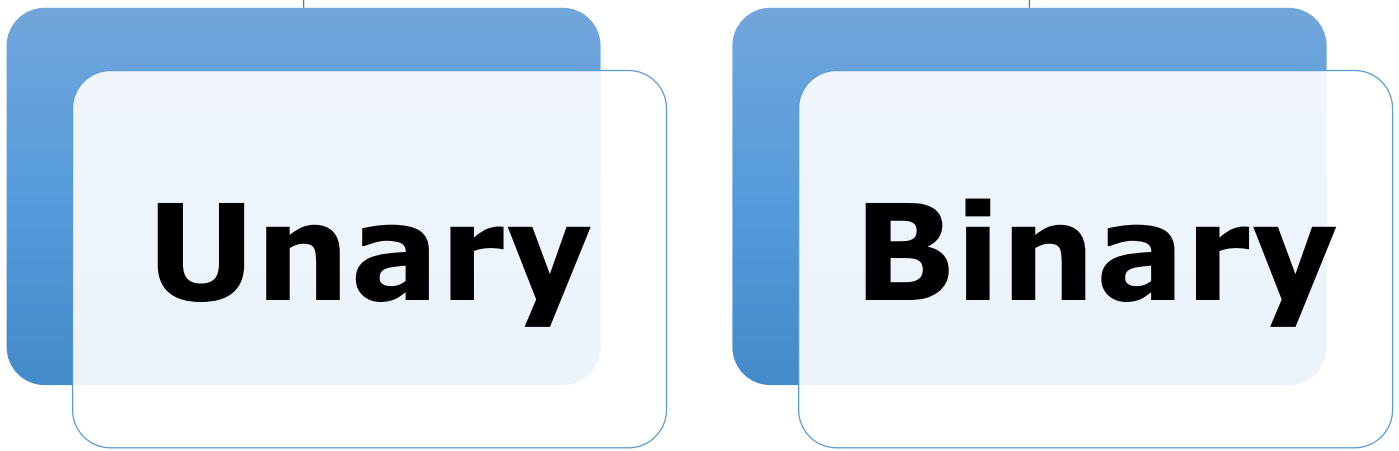
➢ Operators

An **operation** is a mathematical calculation involving zero or more input values (called **operands**) that produces an output value and in mathematics, operators such as + , - , * , / , …etc.

➢ Precedence and Associativity

Category	Operator	Associativity
Postfix	() [] -> . ++ - -	Left to right
Unary	+ - ! ~ ++ - - (type) * & sizeof	Right to left
Multiplicative	* / %	Left to right
Additive	+ -	Left to right
Shift	<< >>	Left to right
Relational	< <= > >=	Left to right
Equality	== !=	Left to right
Bitwise AND	&	Left to right
Bitwise XOR	^	Left to right
Bitwise OR	|	Left to right
Logical AND	&&	Left to right
Logical OR	||	Left to right
Conditional	?:	Right to left
Assignment	= += -= *= /= %= >>= <<= &= ^= |=	Right to left
Comma	,	Left to right

Arithmetic Operators



➢ Arithmetic Operators

➢ Unary

Operator	Symbol	Form	Operation
Unary plus	+	+x	Value of x
Unary minus	-	-x	Negation of x

➢ Binary

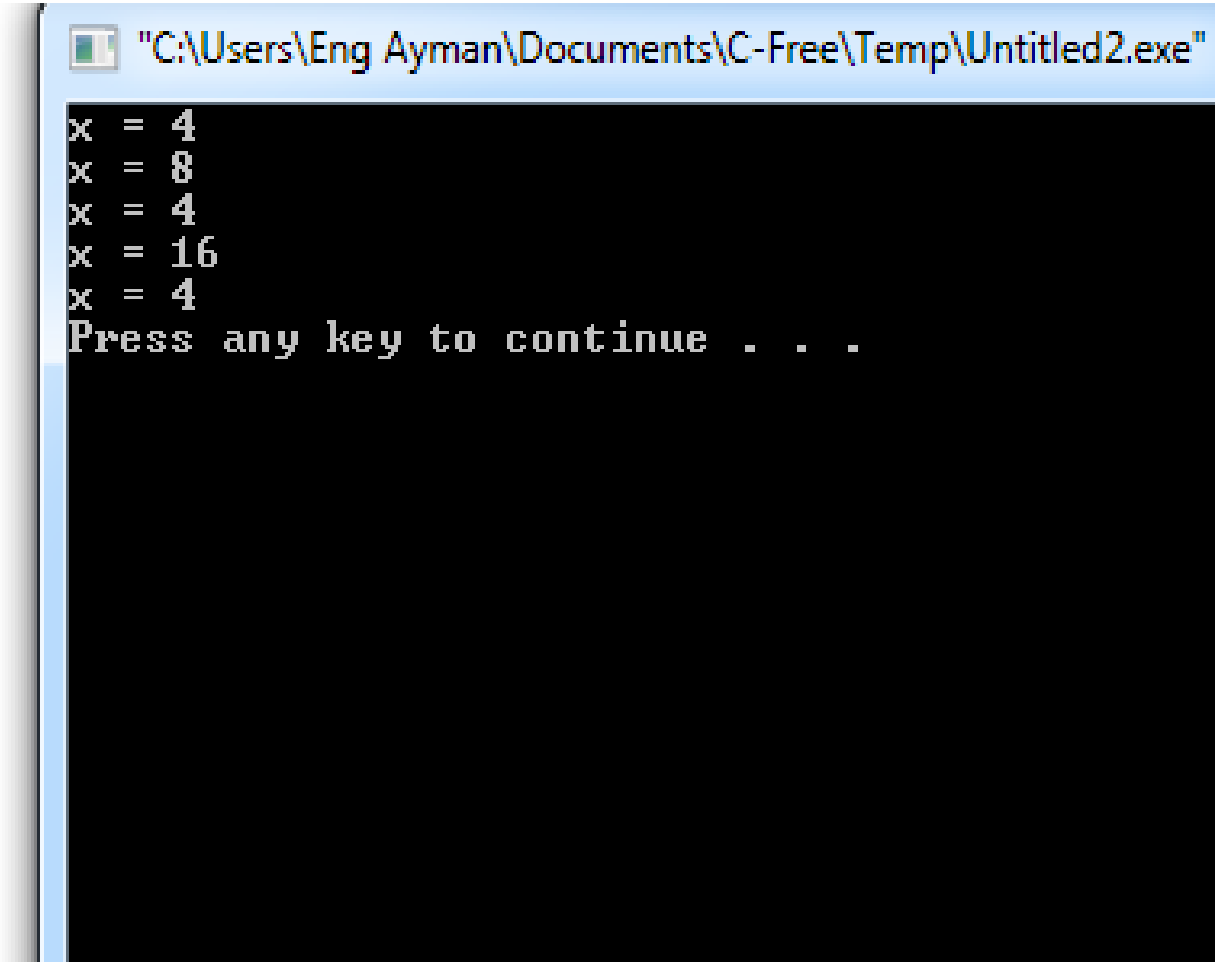
Operator	Symbol	Form	Operation
Addition	+	x + y	x plus y
Subtraction	-	x - y	x minus y
Multiplication	*	x * y	x multiplied by y
Division	/	x / y	x divided by y
Modulus (Remainder)	%	x % y	The remainder of x divided by y

➢ Arithmetic assignment operators

Operator	Symbol	Form	Operation
Assignment	=	x = y	Assign value y to x
Addition assignment	+=	x += y	Add y to x (x = x + y)
Subtraction assignment	-=	x -= y	Subtract y from x (x = x - y)
Multiplication assignment	*=	x *= y	Multiply x by y (x = x * y)
Division assignment	/=	x /= y	Divide x by y (x = x / y)
Modulus assignment	%=	x %= y	Put the remainder of x / y in x (x = x % y)

➢ Example

```
1  #include <iostream.h>
2  int main()
3  {
4      double x=10.5,y=4;
5      x=y;
6      cout<<"x = "<< x <<endl;
7      x += y;
8      cout<<"x = "<< x <<endl;
9      x -= y;
10     cout<<"x = "<< x <<endl;
11     x *= y;
12     cout<<"x = "<< x <<endl;
13     x /= y;
14     cout<<"x = "<< x <<endl;
15     return 0;
16 }
```

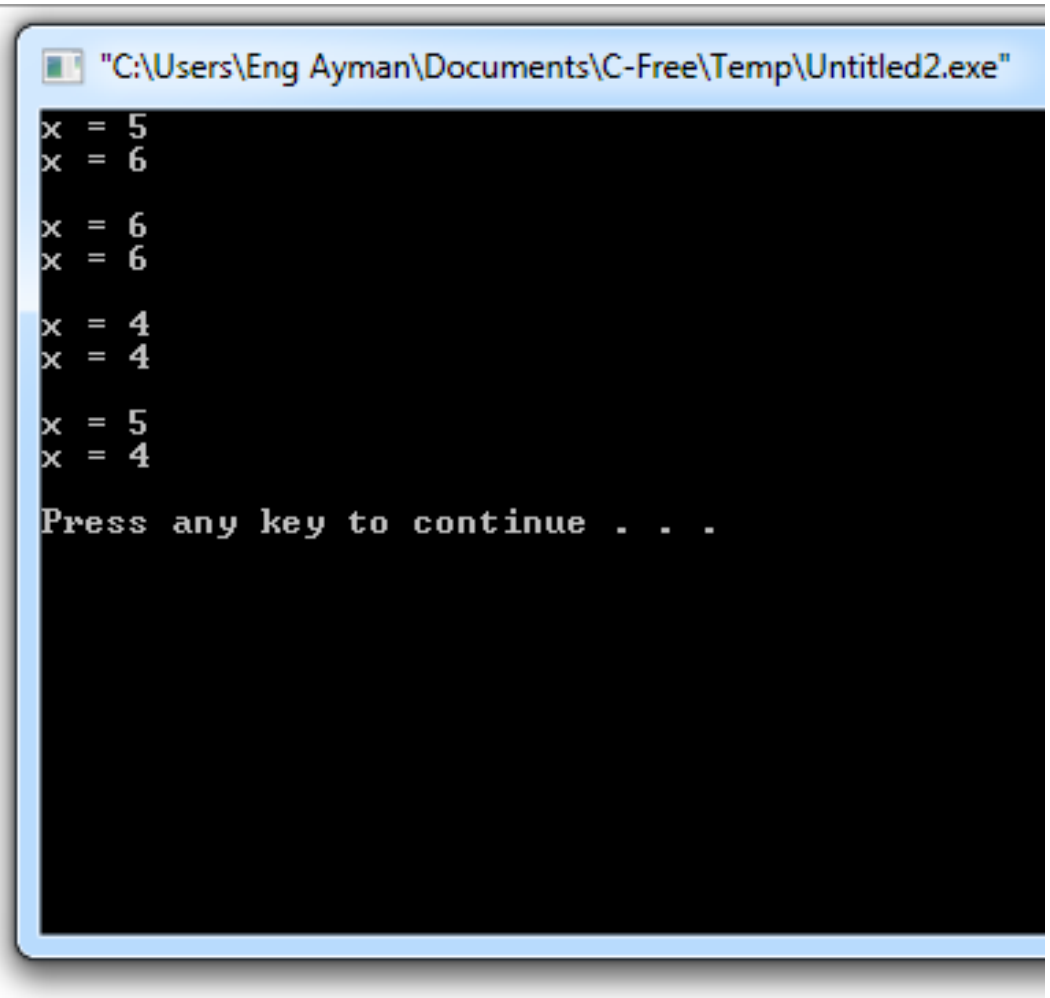


➢ Increment/decrement operators

Operator	Symbol	Form	Operation
Prefix increment (pre-increment)	++	++x	Increment x, then evaluate x
Prefix decrement (pre-decrement)	– –	– –x	Decrement x, then evaluate x
Postfix increment (post-increment)	++	x++	Evaluate x, then increment x
Postfix decrement (post-decrement)	– –	x– –	Evaluate x, then decrement x

➢ Example

```
1  #include <iostream.h>
2  int main()
3  {
4      double x=5;
5      cout<<"x = "<< x++ <<endl;
6      cout<<"x = "<< x <<endl;
7      cout<<endl;
8      x=5;
9      cout<<"x = "<< ++x <<endl;
10     cout<<"x = "<< x <<endl;
11     cout<<endl;
12     x=5;
13     cout<<"x = "<< --x <<endl;
14     cout<<"x = "<< x <<endl;
15     cout<<endl;
16     x=5;
17     cout<<"x = "<< x-- <<endl;
18     cout<<"x = "<< x <<endl;
19     cout<<endl;
20     return 0;
21 }
```



➢ Relational Operators (Comparisons)

Operator	Symbol	Form	Operation
Greater than	>	x > y	true if x is greater than y, false otherwise
Less than	<	x < y	true if x is less than y, false otherwise
Greater than or equals	>=	x >= y	true if x is greater than or equal to y, false otherwise
Less than or equals	<=	x <= y	true if x is less than or equal to y, false otherwise
Equality	==	x == y	true if x equals y, false otherwise
Inequality	!=	x != y	true if x does not equal y, false otherwise

➢ Logical operators

Operator	Symbol	Form	Operation
Logical NOT	!	!x	true if x is false, or false if x is true
Logical AND	&&	x && y	true if both x and y are true, false otherwise
Logical OR	||	x || y	true if either x or y are true, false otherwise

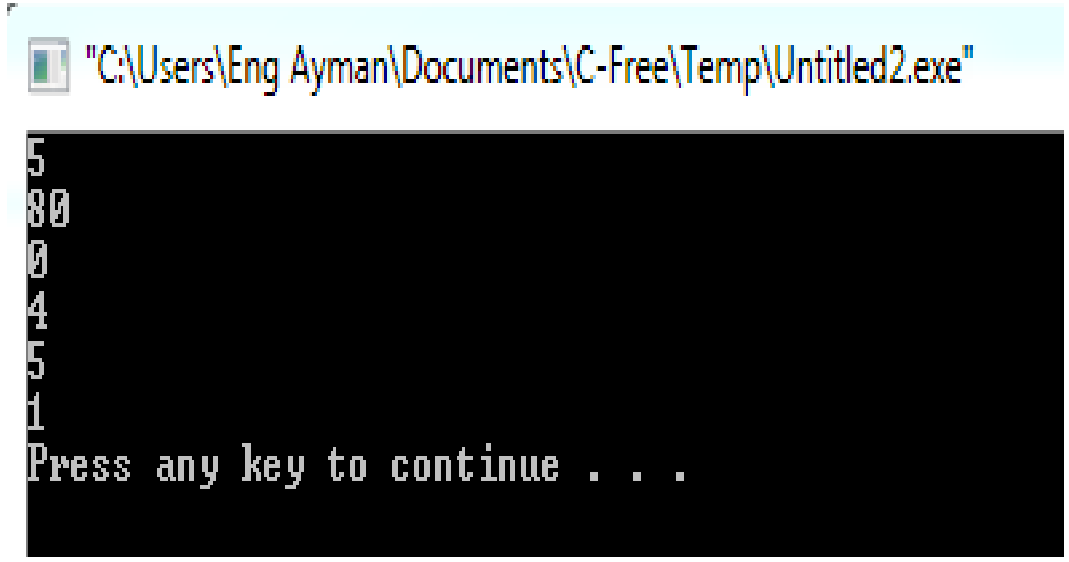
➢ Bitwise Operators

Using bitwise operators, it is possible to write functions that allow us to compact 8 Booleans into a single byte-sized variable, enabling significant memory savings at the expense of more complex code.

Operator	Symbol	Form	Operation
left shift	<<	x << y	all bits in x shifted left y bits
right shift	>>	x >> y	all bits in x shifted right y bits
bitwise NOT	~	~x	all bits in x flipped
bitwise AND	&	x & y	each bit in x AND each bit in y
bitwise OR	|	x | y	each bit in x OR each bit in y
bitwise XOR	^	x ^ y	each bit in x XOR each bit in y

➢ Example

```
#include <iostream.h>
int main()
{
int x = 5, y = 4, z;
cout << x << '\n';    //x= 00000000 00000000 00000000 00000101 = 5
z = x << y;
cout << z << '\n';    //0101 << 4 = 01010000 = 80
z = x >> y;
cout << z << '\n';    //0101 >> 4 = 0000        = zero
z = x & y;
cout << z << '\n';    //0101 & 0100 = 0100     =4
z = x | y;
cout << z << '\n';    //0101 | 0100= 0101      =5
z = x ^ y;
cout << z << '\n';    //0101^0100= 0001        =1
return 0;
}
```

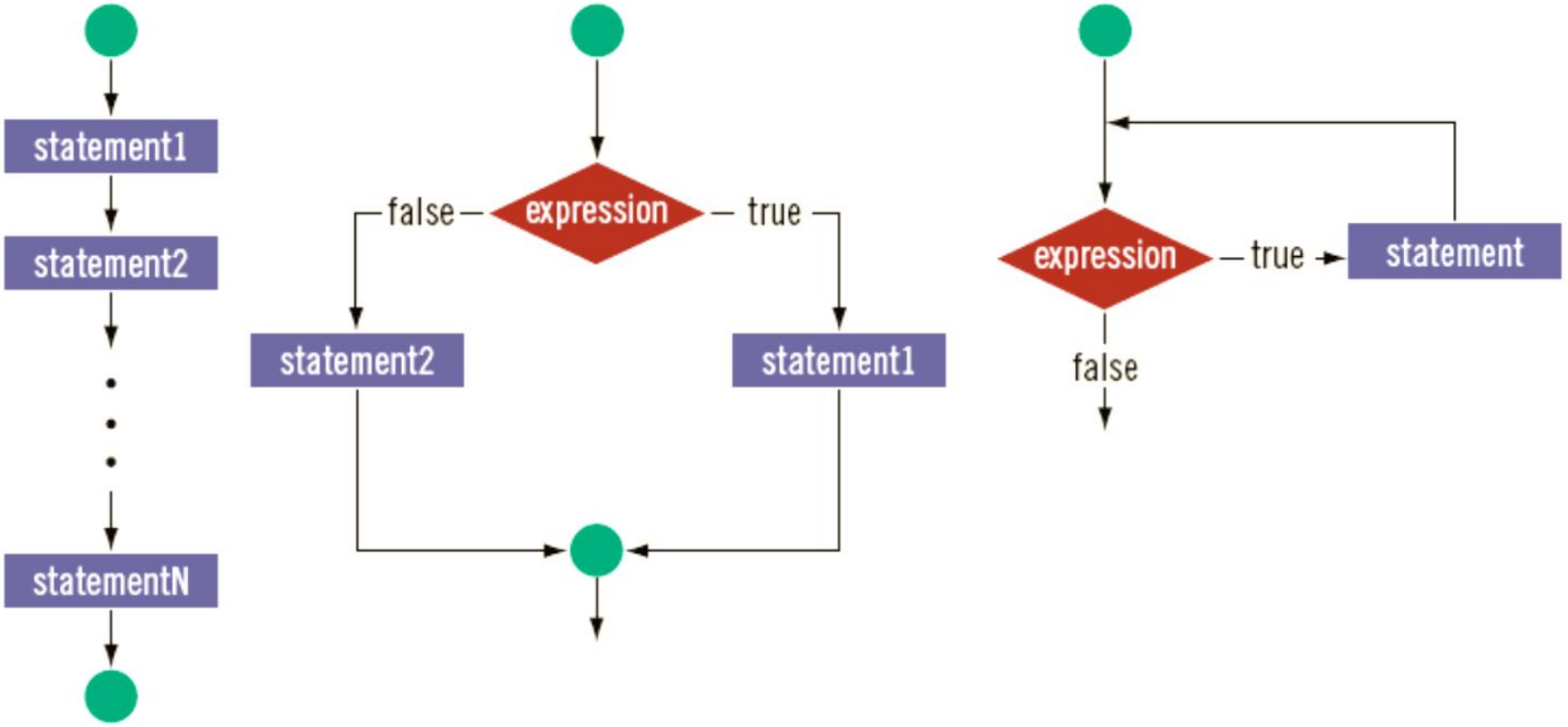


Control Structures

- A computer can proceed:
  - In sequence
  - Selectively (branch) - making a choice
  - Repetitively (iteratively) – looping

- Some statements are executed only if certain conditions are met
- A condition is met if it evaluates to true

➢ Control Structures (cont.)



➢ Relational Operators and Simple Data Types

You can use the relational operators with all three simple data types:

In the following example, the expressions use both integers and real numbers:

8 < 15 evaluates to →true

6 != 6 evaluates to →false

2.5 > 5.8 evaluates to →false

5.9 <= 7.5 evaluates to →true

➢ Comparing Characters

ASCII Value	Char	ASCII Value	Char	ASCII Value	Char	ASCII Value	Ch
32	' '	61	=	81	Q	105	i
33	!	62	>	82	R	106	j
34	"	65	A	83	S	107	k
42	*	66	B	84	T	108	l
43	+	67	C	85	U	109	m
45	-	68	D	86	V	110	n
47	/	69	E	87	W	111	o
48	0	70	F	88	X	112	p
49	1	71	G	89	Y	113	q
50	2	72	H	90	Z	114	r
51	3	73	I	97	a	115	s
52	4	74	J	98	b	116	t
53	5	75	K	99	c	117	u
54	6	76	L	100	d	118	v
55	7	77	M	101	e	119	w
56	8	78	N	102	f	120	x
57	9	79	O	103	g	121	y
60	<	80	P	104	h	122	z

Expression	Value of Expression	Explanation
`' ' < 'a'`	`true`	The ASCII value of `' '` is 32, and the ASCII value of `'a'` is 97. Because 32 < 97 is `true`, it follows that `' ' < 'a'` is `true`.
`'R' > 'T'`	`false`	The ASCII value of `'R'` is 82, and the ASCII value of `'T'` is 84. Because 82 > 84 is `false`, it follows that `'R' > 'T'` is `false`.
`'+' < '*'`	`false`	The ASCII value of `'+'` is 43, and the ASCII value of `'*'` is 42. Because 43 < 42 is `false`, it follows that `'+' < '*'` is `false`.
`'6' <= '>'`	`true`	The ASCII value of `'6'` is 54, and the ASCII value of `'>'` is 62. Because 54 <= 62 is `true`, it follows that `'6' <= '>'` is `true`.

➢ Relational Operators and the string Type

- Relational operators can be applied to strings
- Strings are compared character by character, starting with the first character
- Comparison continues until either a mismatch is found, or all characters are found equal
- If two strings of different lengths are compared and the comparison is equal to the last character of the shorter string
  - The shorter string is less than the larger string

➢ Example

Suppose we have the following declarations:

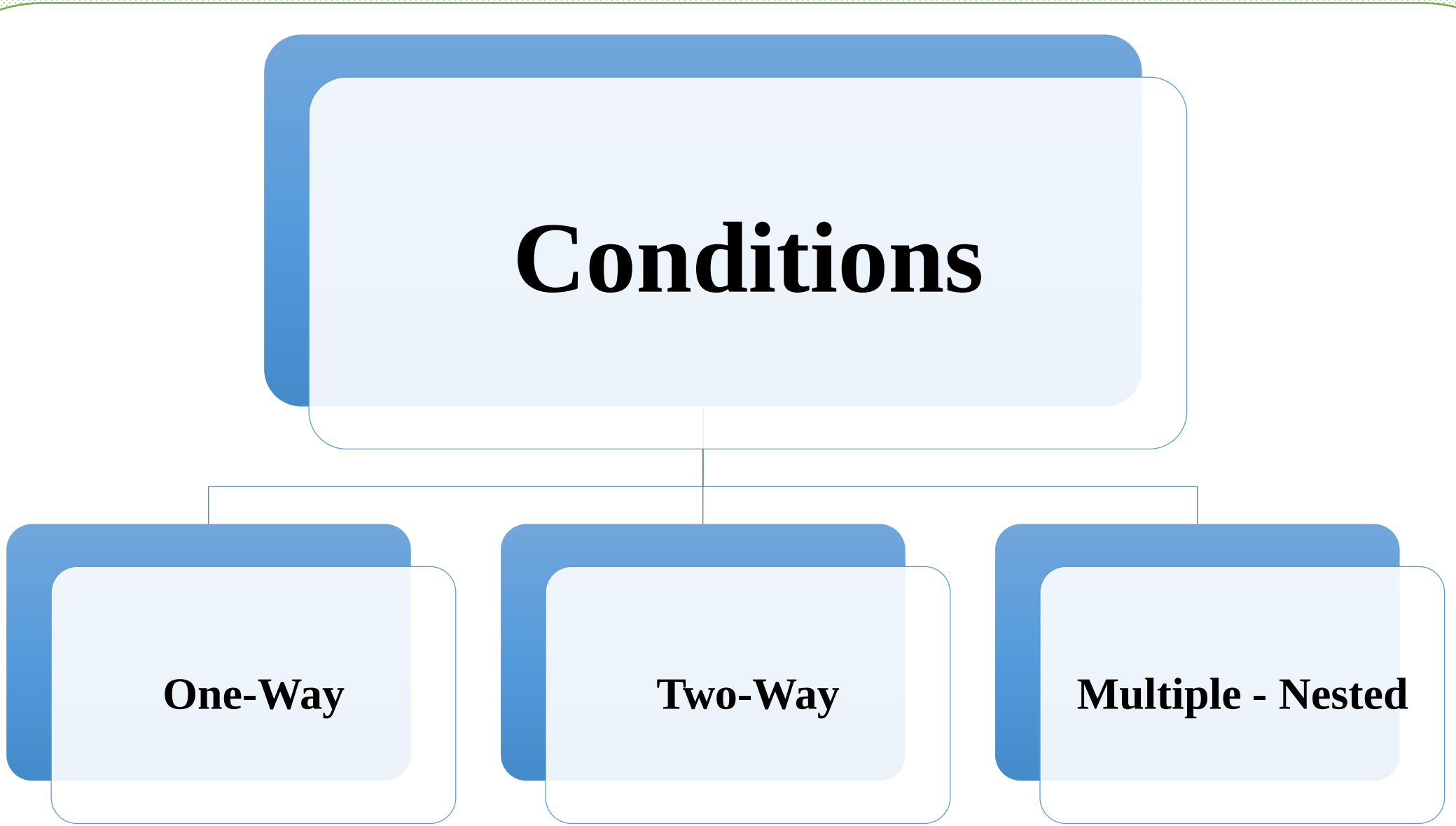
```
string str1 = "Hello";
string str2 = "Hi";
string str3 = "Air";
string str4 = "Bill";
string str4 = "Big";
```

Expression	Value	Explanation
`str1 < str2`	`true`	`str1 = "Hello"` and `str2 = "Hi"`. The first characters of `str1` and `str2` are the same, but the second character `'e'` of `str1` is less than the second character `'i'` of `str2`. Therefore, `str1 < str2` is `true`.
`str1 > "Hen"`	`false`	`str1` = `"Hello"`. The first two characters of `str1` and `"Hen"` are the same, but the third character `'l'` of `str1` is less than the third character `'n'` of `"Hen"`. Therefore, `str1 > "Hen"` is `false`.
`str3 < "An"`	`true`	`str3 = "Air"`. The first characters of `str3` and `"An"` are the same, but the second character `'i'` of `"Air"` is less than the second character `'n'` of `"An"`. Therefore, `str3 < "An"` is `true`.

➢ Example

Expression	Value	Explanation
`str4 >= "Billy"`	`false`	`str4 = "Bill"`. It has four characters and `"Billy"` has five characters. Therefore, `str4` is the shorter string. All four characters of `str4` are the same as the corresponding first four characters of `"Billy"`, and `"Billy"` is the larger string. Therefore, `str4 >= "Billy"` is `false`.
`str5 <= "Bigger"`	`true`	`str5 = "Big"`. It has three characters and `"Bigger"` has six characters. Therefore, `str5` is the shorter string. All three characters of `str5` are the same as the corresponding first three characters of `"Bigger"`, and `"Bigger"` is the larger string. Therefore, `str5 <= "Bigger"` is `true`.

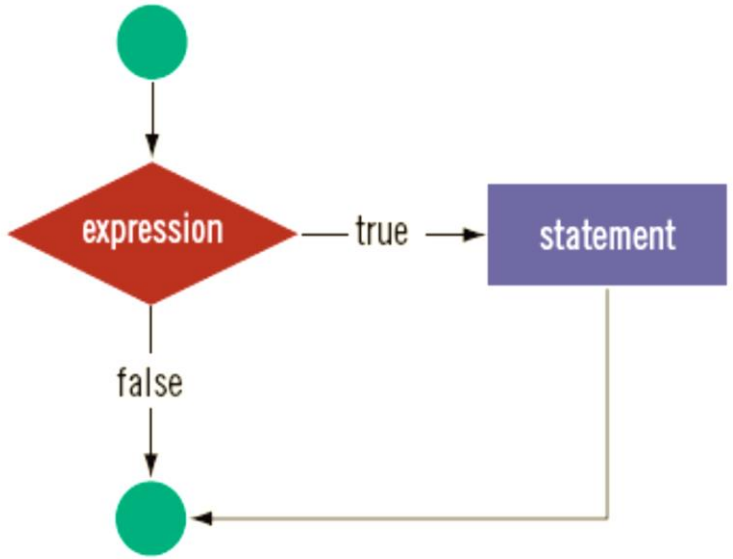
Expression	Value	Explanation
`str1 == "hello"`	`false`	`str1 = "Hello"`. The first character `'H'` of `str1` is less than the first character `'h'` of `"hello"` because the ASCII value of `'H'` is 72, and the ASCII value of `'h'` is 104. Therefore, `str1 == "hello"` is `false`.
`str3 <= str4`	`true`	`str3 = "Air"` and `str4 = "Bill"`. The first character `'A'` of `str3` is less than the first character `'B'` of `str4`. Therefore, `str3 <= str4` is `true`.
`str2 > str4`	`true`	`str2 = "Hi"` and `str4 = "Bill"`. The first character `'H'` of `str2` is greater than the first character `'B'` of `str4`. Therefore, `str2 > str4` is `true`.


Conditions
One-Way
Two-Way
Multiple - Nested

➢ One-Way Selection

The syntax of one-way selection is:

```
if (expression)
    statement
```



- ❑ The statement is executed if the value of the expression is true
- ❑ The statement is bypassed if the value is false; program goes to the next statement
- ❑ if is a reserved word

➢ One-Way Selection (syntax error)

Consider the following statement:

```
if score >= 60      //syntax error
   grade = 'P';
```

This statement illustrates an incorrect version of an `if` statement. The parentheses around the logical expression are missing, which is a syntax error.

Consider the following C++ statements:

```
if (score >= 60);          //Line 1
    grade = 'P';           //Line 2
```

Because there is a semicolon at the end of the expression (see Line 1), the `if` statement in Line 1 terminates. The action of this `if` statement is null, and the statement in Line 2 is not part of the `if` statement in Line 1. Hence, the statement in Line 2 executes regardless of how the `if` statement evaluates.

➢ Example

The following C++ program finds the absolute value of an integer:

```
//Program: Absolute value of an integer

#include <iostream>

using namespace std;

int main()
{
    int number, temp;

    cout << "Line 1: Enter an integer: ";          //Line 1
    cin >> number;                                 //Line 2
    cout << endl;                                  //Line 3

    temp = number;                                 //Line 4

    if (number < 0)                                //Line 5
        number = -number;                          //Line 6

    cout << "Line 7: The absolute value of "
         << temp << " is " << number << endl;      //Line 7

    return 0;
}
```

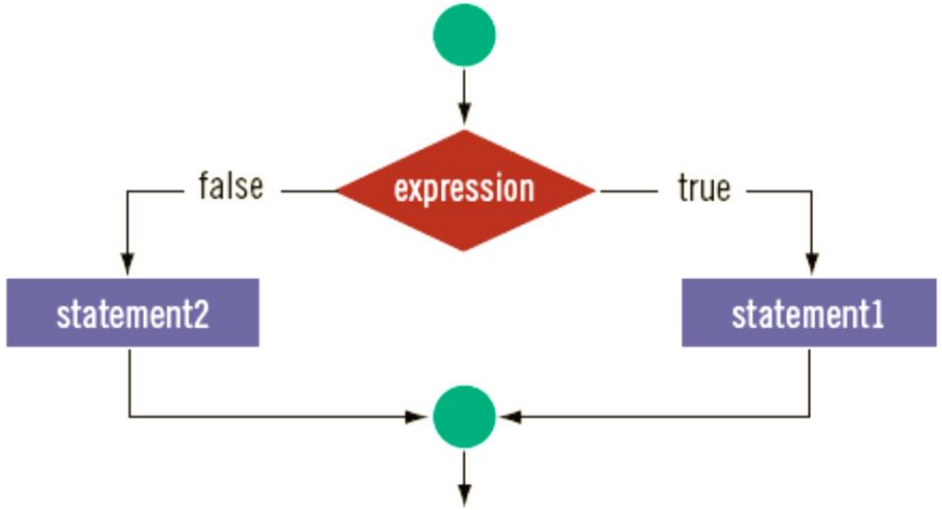
Sample Run: In this sample run, the user input is shaded.

```
Line 1: Enter an integer: -6734
Line 7: The absolute value of -6734 is 6734
```

➢ Two-Way Selection

Two-way selection takes the form:

```
if (expression)
    statement1
else
    statement2
```



- If expression is true, statement1 is executed; otherwise, statement2 is executed
  - statement1 and statement2 are any C++ statements
- else is a reserved word

Example→ Consider the following statements:

```
if (hours > 40.0)                                  //Line 1
    wages = 40.0 * rate +
            1.5 * rate * (hours - 40.0);           //Line 2
else                                               //Line 3
    wages = hours * rate;                          //Line 4
```

➢ Compound (Block of) Statement

Compound statement (block of statements):

```
{
    statement1
    statement2
       .
       .
       .
    statementn
}
```

➢ Multiple Selections: Nested if

- ❑ Nesting: one control statement in another
- ❑ An else is associated with the most recent if that has not been paired with an else

Suppose that balance and interestRate are variables of type double. The following statements determine the interestRate depending on the value of the balance:

```
if (balance > 50000.00)                  //Line 1
    interestRate = 0.07;                 //Line 2
else                                     //Line 3
    if (balance >= 25000.00)             //Line 4
        interestRate = 0.05;             //Line 5
    else                                 //Line 6
        if (balance >= 1000.00)          //Line 7
            interestRate = 0.03;         //Line 8
        else                             //Line 9
            interestRate = 0.00;         //Line 10
```

most efficient method

```
if (balance > 50000.00)
    interestRate = 0.07;
else if (balance >= 25000.00)
    interestRate = 0.05;
else if (balance >= 1000.00)
    interestRate = 0.03;
else
    interestRate = 0.00;
```

➢ Example

Assume that `score` is a variable of type `int`. Based on the value of `score`, the following code outputs the grade:

```
if (score >= 90)
    cout << "The grade is A." << endl;
else if (score >= 80)
    cout << "The grade is B." << endl;
else if (score >= 70)
    cout << "The grade is C." << endl;
else if (score >= 60)
    cout << "The grade is D." << endl;
else
    cout << "The grade is F." << endl;
```

➢ Comparing if…else Statements with a Series of if Statements

First method

```
if (month == 1)
    cout << "January" << endl;
if (month == 2)
    cout << "February" << endl;
if (month == 3)
    cout << "March" << endl;
if (month == 4)
    cout << "April" << endl;
if (month == 5)
    cout << "May" << endl;
if (month == 6)
    cout << "June" << endl;
```

Second method

```
if (month == 1)
    cout << "January" << endl;
else if (month == 2)
    cout << "February" << endl;
else if (month == 3)
    cout << "March" << endl;
else if (month == 4)
    cout << "April" << endl;
else if (month == 5)
    cout << "May" << endl;
else if (month == 6)
    cout << "June" << endl;
```

➢ **Which method is preferred?**

➢ Associativity of Relational Operators:

```
#include <iostream>

using namespace std;

int main()
{
     int num;

     cout << "Enter an integer: ";
     cin >> num;
     cout << endl;

     if (0 <= num <= 10)
         cout << num << " is within 0 and 10." << endl;
     else
         cout << num << " is not within 0 and 10." << endl;

     return 0;
}
```

Solution:

Sample Runs:

Sample Run 1:

Enter an integer: 5

5 is within 0 and 10. (correct)

Sample Run 2:

Enter an integer: 20

20 is within 0 and 10. (incorrect)

Sample Run 3:

Enter an integer: -10

-10 is within 0 and 10. (incorrect)

`0 <= num <= 10`	`= 0 <= 5 <= 10`	
	`= (0 <= 5) <= 10`	(Because relational operators are evaluated from left to right)
	`= 1 <= 10`	(Because `0 <= 5` is `true`, `0 <= 5` evaluates to 1)
	`= 1 (true)`	

Now, suppose that `num = 20`. Then:

`0 <= num <= 10`	`= 0 <= 20 <= 10`	
	`= (0 <= 20) <= 10`	(Because relational operators are evaluated from left to right)
	`= 1 <= 10`	(Because `0 <= 20` is `true`, `0 <= 20` evaluates to 1)
	`= 1 (true)`	

(0 <= num && num <= 10)

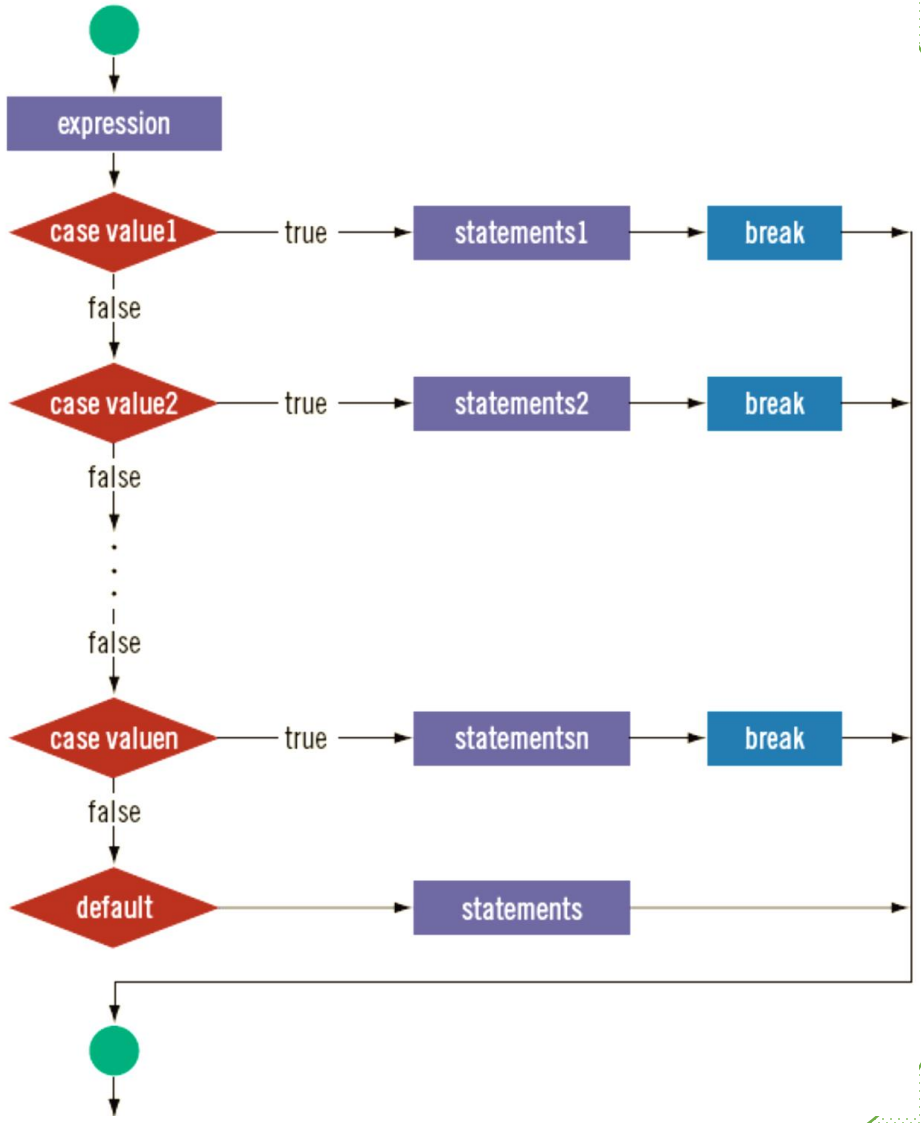
➢ switch Structures

- ❑ switch structure: alternate to if-else
- ❑ switch (integral) expression is evaluated first
- ❑ Value of the expression determines which corresponding action is taken
- ❑ Expression is sometimes called the selector

```
switch (expression)
{
case value1:
    statements1
    break;
case value2:
    statements2
    break;
    .
    .
    .
case valuen:
    statementsn
    break;
default:
    statements
}
```

➢ switch Structures (cont.)

- One or more statements may follow a case label
- Braces are not needed to turn multiple statements into a single compound statement
- The break statement may or may not appear after each statement
- switch, case, break, and default are reserved words



➢ Example

Consider the following statements, where grade is a variable of type **char**:

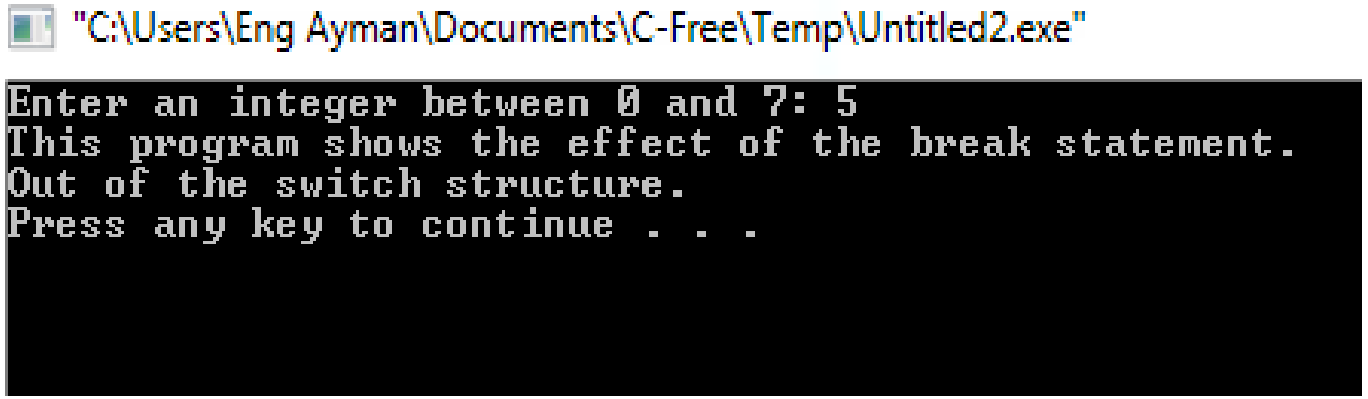
```
switch (grade)
{
case 'A':
    cout << "The grade is 4.0.";
    break;
case 'B':
    cout << "The grade is 3.0.";
    break;
case 'C':
    cout << "The grade is 2.0.";
    break;
case 'D':
    cout << "The grade is 1.0.";
    break;
case 'F':
    cout << "The grade is 0.0.";
    break;
default:
    cout << "The grade is invalid.";
}
```

In this example, the expression in the **switch** statement is a variable identifier. The variable **grade** is of type **char**, which is an integral type. The possible values of **grade** are **'A'**, **'B'**, **'C'**, **'D'**, and **'F'**. Each **case** label specifies a different action to take, depending on the value of **grade**. If the value of **grade** is **'A'**, the output is:

```
The grade is 4.0.
```

➢ Example (attention)

```
int main()
{
        int num;
            cout << "Enter an integer between 0 and 7: ";
            cin >> num;
    switch(num)
            {
            case 0:
            case 1:
            cout << "Learning to use ";
            case 2:
            cout << "C++'s ";
            case 3:
            cout << "switch structure." << endl;
            break;
            case 4:
            break;
            case 5:
            cout << "This program shows the effect ";
            case 6:
            case 7:
            cout << "of the break statement." << endl;
            break;
            default:
            cout << "The number is out of range." << endl;
            }
    cout << "Out of the switch structure." << endl;
    return 0;
    }
```



Thank you